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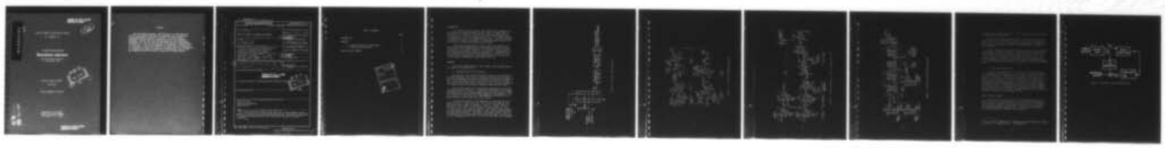

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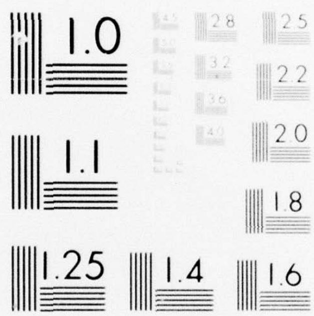

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ADAPTIVE ARRAYS FOR AM AND FM SIGNALS

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This report describes progress under Naval Air Systems Command Contract N00019-77-C-0156 during the second quarterly period. Research on the problem of integrating adaptive arrays into conventional modulation systems is summarized.

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INTRODUCTION

This report describes progress under NASC Contract N00019-77-C-0156 during the second quarterly period. There are three areas of work under this contract. The first involves experimental tests of an adaptive array in an AM communication system. The second involves array experiments with an FM communication system. The third consists of theoretical studies of methods of integrating adaptive arrays into other types of conventional communication systems.

The AM and FM communication systems involve the addition of a binary phase switching modulation on conventional AM and FM signals. The purpose of this phase switching is to allow the array to distinguish between the desired signal and interference. Implementation of the system with this phase switching requires an IF delay lock loop for the AM system and a Costas Loop and baseband delay lock loop for the FM system, in addition to other minor circuitry.

PROGRESS

During the second quarter of this program, work has been done in two areas, as discussed below.

1. Implementation of the AM System

Design work on the signal processing circuitry for the AM system has been completed. All circuitry for generating and for receiving the biphase modulated AM signal has been built and tested in breadboard form. The major effort here has involved the design of an IF delay lock loop and associated signal acquisition circuitry to be used behind the adaptive array for providing a properly timed reference signal.

The desired signal to be received by the adaptive array will be generated as shown in Figure 1. An AM signal generated by an HP-8640B signal generator will be biphase modulated using a Minicircuits Laboratory SRA-1 mixer driven by an HP1930A pseudonoise code generator. The mixer output will be filtered to 6 KHz bandwidth and then split in a power divider to provide the array input signals.

The reference signal will be generated by processing the array output signal in a delay lock loop. The circuitry designed for the delay-lock loop is shown in Figures 2, 3 and 4. Figure 2 shows the RF portion of the loop. The 10.7 MHz array output signal is first limited and then split into two channels. The signal in each channel is mixed against a PN coded 10.6 MHz LO signal, with the code displaced one chip between channels. The output is filtered to retain the 100 KHz product, which is then mixed with a 99 KHz CW signal to bring the carrier frequency down to 1 KHz. An active filter with 10 Hz bandwidth

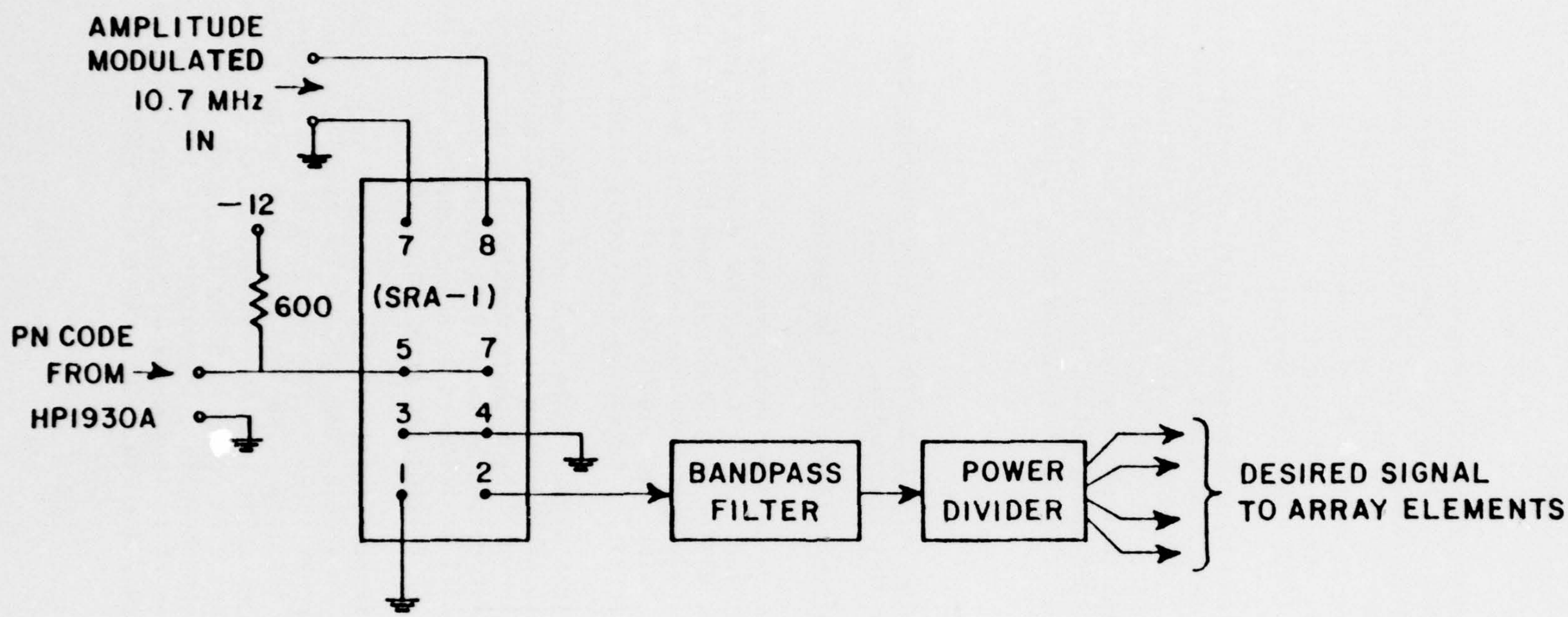

Figure 1. Desired signal generation.

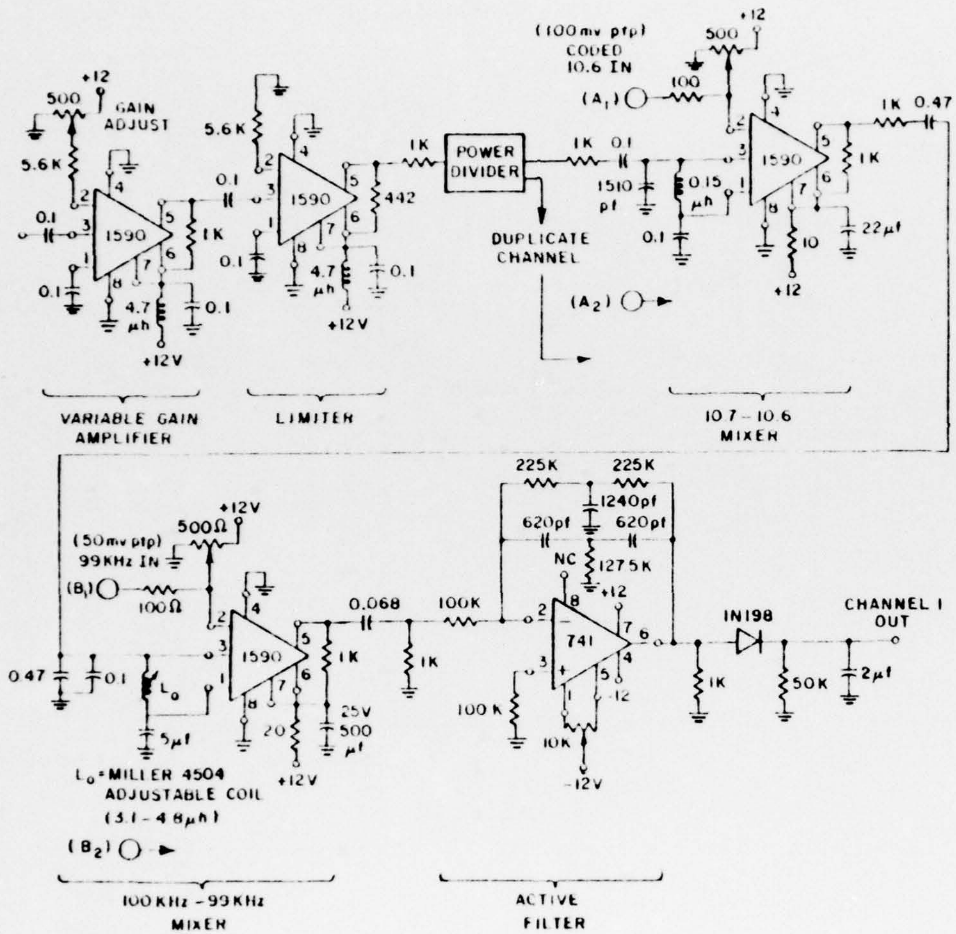

Figure 2. RF portion of delay lock loop.

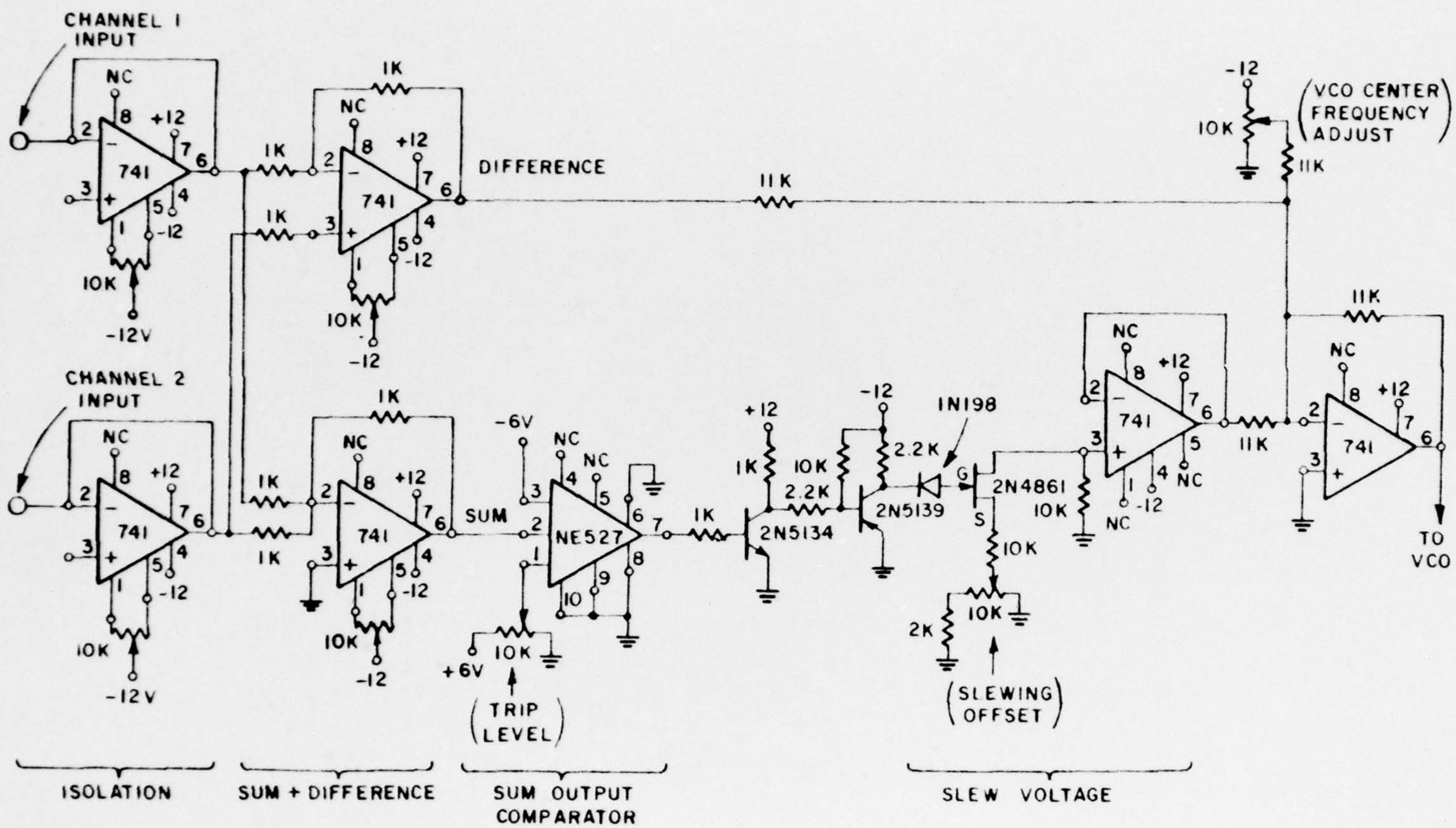

Figure 3. Sum and difference circuits in delay lock loop.

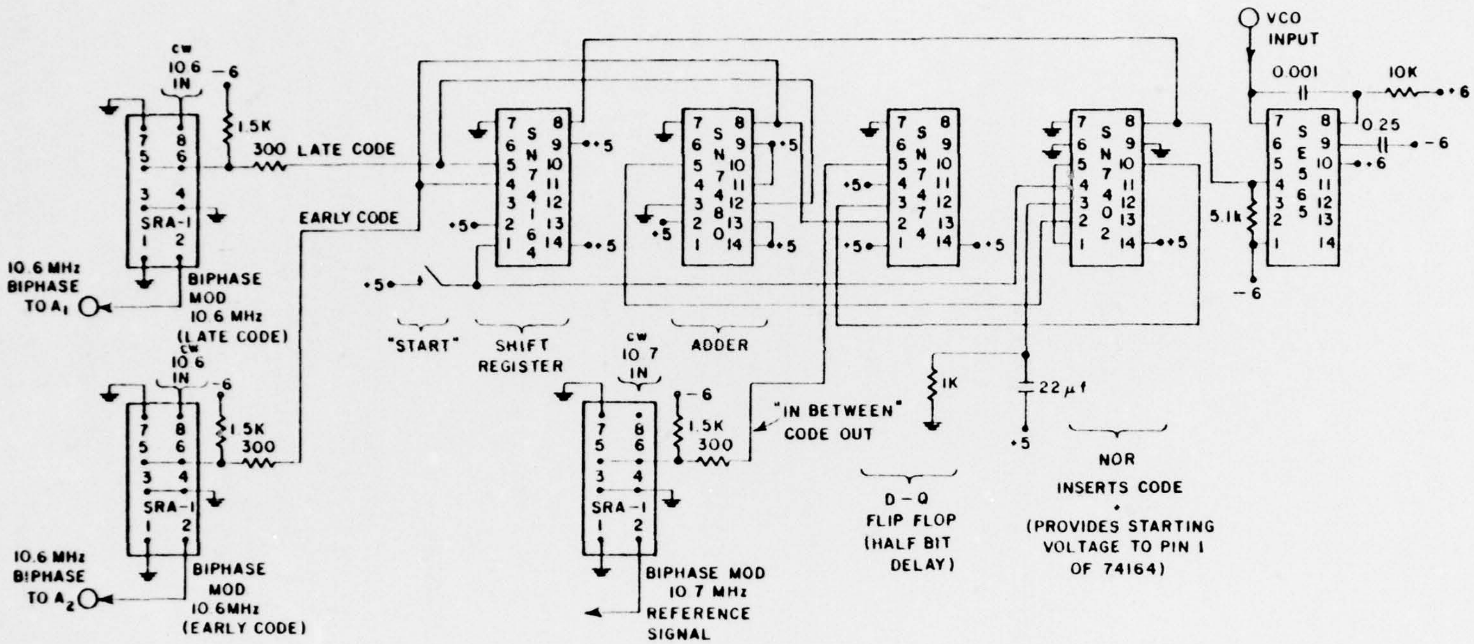

Figure 4. Digital portion of delay lock loop.

is used to filter the 1 KHz signal. The filter output on each channel is then envelope demodulated.

Figure 3 shows the baseband circuits used to derive the sum and difference voltages from the two channels in Figure 2. Figure 3 also shows the circuitry used to compare the sum voltage to a threshhold and to provide the VCO with a slewing voltage when the sum output is below threshhold.

Figure 4 shows the VCO and the digital circuitry used to generate two PN codes separated by one chip. These two digital waveforms are biphase modulated on two 10.6 MHz CW signals with SRA-1 mixers to provide the two LO signals used at the first mixers in Figure 2. The digital circuitry in Figure 4 also generates a third PN code timed half way between the other two codes. This code is biphase modulated on a 10.7 MHz CW signal to provide the reference signal for the adaptive array.

2. Studies on FM Modulation

Studies begun under the previous contract (N00019-76-C-0195) on the performance of an adaptive array with biphase modulated FM signals have been completed. A report* has been written showing the major results of this study. Unlike the case with AM, it is clear that with FM it will be necessary to include an estimate of the information modulation in the reference signal. To do this will require a Costas Loop demodulator and a baseband delay lock loop at the array output, as shown in Figure 5. Eliminating the Costas Loop estimation appears to be feasible only for narrowband FM. The report contains necessary design information on the tradeoffs between modulation delay, frequency deviation, code delay, and frequency offsets.

PLANS FOR NEXT QUARTER

During the next quarter, the circuitry described above for the AM system will be built in finished form. Testing of the adaptive array performance with AM signals will then be started. Also, during the next quarter, design and breadboard testing will be started for the components needed in the FM system -- the Costas Loop and Delay Lock Loop required for reference signal generation.

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*I.K. Lao and R.T. Compton, Jr., "Adaptive Array Performance with Coded FM Signals," ESL Report 4618-2. In preparation.

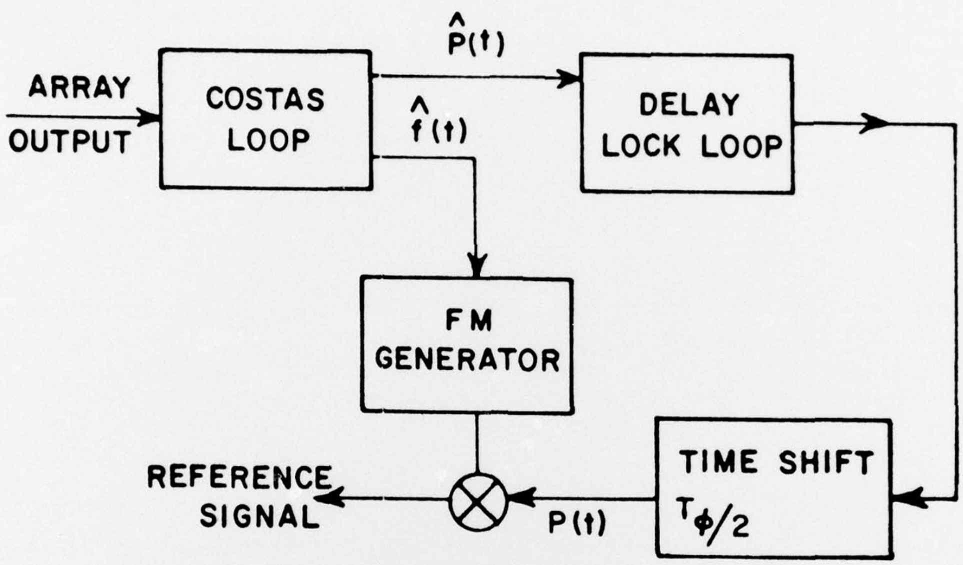

Figure 5. Reference signal generation loop.